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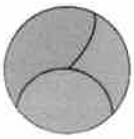

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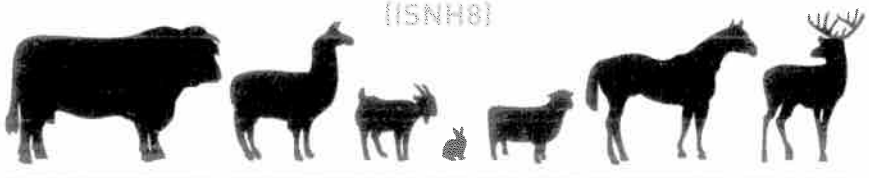

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Effects of pasture type and animal breed on bone metabolism of lambs grazing high altitude grasslands

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Introduction High alpine grasslands serve as feed resource for ruminant livestock species during summer. Low feed density and the steep slopes in alpine regions require large movement activities of the grazing animal (Liesegang *et al.*, 2010). Due to their body size, sheep are well adapted to graze on those topographically and climatically harsh environments. Depending on magnitude and rate of strain, movement activities may influence bone metabolism in different ways (Bass *et al.*, 2005). The present study aimed at investigating the effects of grazing on different alpine pasture types, characterised by vegetation type, slope and Ca content, and animal breed on bone metabolism of lambs.

Material and methods Lambs of two Swiss mountain breeds, Engadin Sheep (ES, 27; castrated males) and Valasian Black Nose Sheep (VS; 28; castrated males and females, 4:3), grazed for 9 weeks in paddocks allowing *ad libitum* forage intake on the following four pasture types: lowland control red/white clover-ryegrass ley, 0 % slope at 400 m a.s.l. (C), alpine *Crepido aurea-Festucetum* pasture, 0-5 % slope at 1950 m a.s.l. (F), alpine *Geo montani-Nardetum* pasture, >40 % slope at 2250 m a.s.l. (G) and alpine *Seslerio-Caricetum sempervirentis* pasture, >40 % slope at 2150 m a.s.l. (S). The initial live weights were 32.7±3.5 kg and 30.8±3.0 kg and ages were 26±2 and 18±7 weeks for ES and VS, respectively. Animals were balanced for gender, weight and age. Before and after the experimental period, markers of bone formation (bAP, bone-specific alkaline phosphatase) and bone resorption (ICTP, cross-linked carboxyterminal telopeptide of type I collagen) were analysed in blood samples and bone mineral density (BMD), bone mineral content (BMC) and cortical thickness (CT) measurements were conducted with peripheral quantitative computer tomography (pQCT) in the middle of the diaphysis on the left metatarsus. After slaughtering, maximum force (MF) to break the left metatarsus in the middle of the diaphysis was analyzed. Concentrations of Calcium (Ca) were analysed with COBAS MIRA®Autoanalyser in one pooled forage samples per pasture type. Data was subjected to analysis of variance considering pasture type, breed and the interaction of both. Furthermore, Pearson correlation coefficients were computed.

Results Concentrations (% DM) of Ca in forage samples were 0.54, 0.97, 0.50 and 1.62 for the pasture types C, F, G and S respectively, indicating a large variation in Ca supply of the lambs on the different pasture types. A trend (P=0.054) was found for a breed × pasture type interaction of BMD development. BMD increased during the experiment for ES by 101.6, 15.5, 24.8 and 48.1 mg/cm³ and for VS by 40.9, 97.5, 168.6 and 50.9 mg/cm³ on the pasture types C, F, G and S, respectively. The BMC increased during the experimental period for ES by 32.3 and 6.5 mg/cm and for VS by 5.0 and 33.8 mg/cm on C and F and even decreased for ES by 2.9 and 10.8 mg/cm and for VS by 22.8 and 10.6 on G and S, respectively. This results in pasture type differences (P<0.001), as well as a breed × pasture type interaction (P<0.001) for BMC development. The CT increased across all pasture types for both breeds during the experiment, but again (like for BMD) the increase in CT was higher for ES on C and for VS on the three alpine pastures (F, G and S), resulting in a significant breed × pasture type interaction (P=0.02). Further, a significant breed × pasture type interaction (P=0.004) as well as a significant breed difference (P=0.001) were found for MF to break the metatarsi in its middle. Metatarsi of VS were less stable than those of ES on the pasture types C, G and S while this was opposite for F. The qQCT measurements at the end of the experiment showed interestingly similar pattern for BMC, MF, BMD and CT although the development of those parameters during the experiment followed different ways. Close correlations were found between MF and BMC (R^2 =0.93; P<0.001) and between CT and BMD (r=0.94; P<0.001). Between BMC and BMD a significant correlation only developed during the experiment, with r=0.80 (P<0.001) at the end compared to r= 0.25 (P=0.064) at the beginning of the experiment. Calculation of modelling/remodelling rate (RMR) by dividing bAP through ICTP on both sampling dates gave a punctual impression of the bone metabolism of the lambs at those two specific dates. Significant pasture type differences (P<0.001) were found for RMR, as values decreased slightly during the experiment for both breeds on C and more clearly on G, whereas the decrease was remarkably stronger on both pasture types for ES than VS. This indicates that bone resorption outweighed bone formation processes, which corresponds with low Ca concentrations on C and G. Additionally, ES appears to be more sensitive in bone marker responds than VS. The RMR increased for both breeds during the experiment clearly on F and moderately on S, pointing towards facilitated bone formation processes on those pastures that had higher Ca concentration in the forage (F and S) compared to low Ca input pastures.

Conclusion Breed × pasture type interactions were found for BMC and CT development and also a trend for interactions for BMD development, indicating a different adaption of the two breeds to mountain pastures. The VS profit more from high alpine grazing compared to lowland grazing in terms of CT and BMD development while this was opposite for ES. The differences in alpine pastures characteristics, especially in slope, nutritional supply and also the individual movement behaviour of the lambs appear to influence BMC and RMR development throughout alpine grazing. Pasture types, including all characteristics mentioned, do have an important effect on bone metabolism of lambs and are tolerated by breeds to a different extent.

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